Basic Radiological Anatomy of the Musculoskeletal system on CT and MRI

Hawler Medical University
College of Medicine
Department of Surgery
Radiology Department

Objectives :

-To understand the appearance of different tissue types on CT and MRI

.

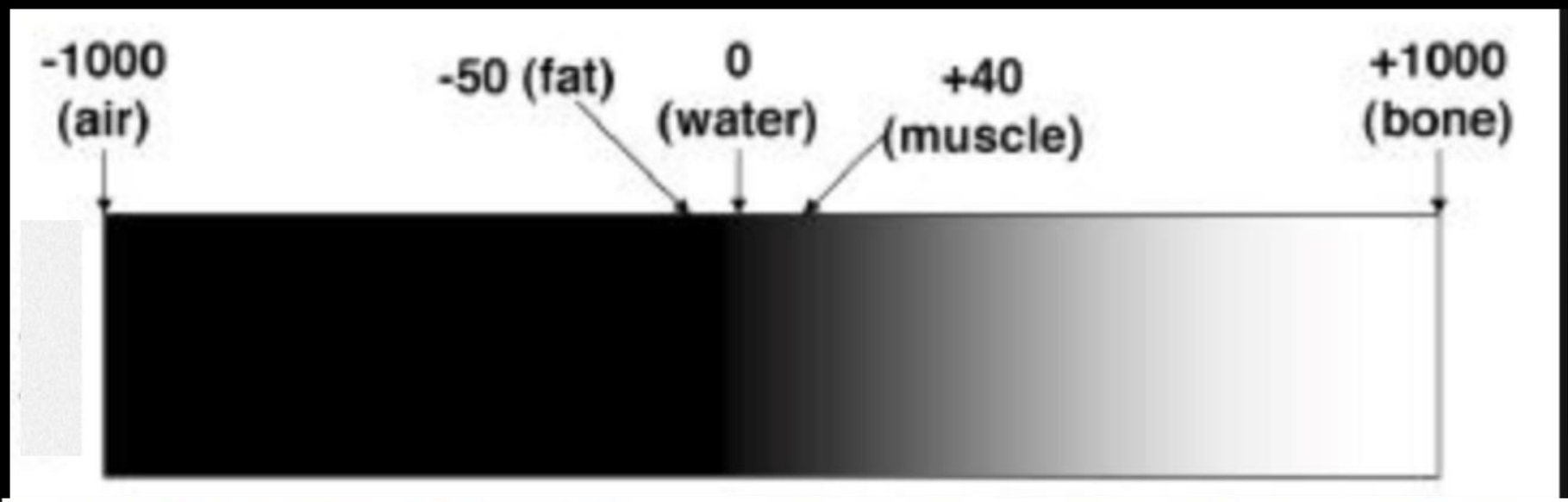
-To recognize the basic anatomical structures related to the MSK system on CT and MRI.

CT scan

-CT uses a computer to reconstruct mathematically a cross-sectional image of the body from measurements of x-ray transmission through thin slices of patient tissue.
-The x-ray beam is attenuated by absorption and scatter as it passes through the patient.
-CT numbers are assigned to each pixel in the image by a computer algorithm that uses as data these measurements of transmitted x-rays.

A Hounsfield unit (HU) scale, named for Sir Godfrey N. Hounsfield, the inventor of CT, is used. Water is assigned a value of 0 H, with the scale extending from 1,024 H for air to +3,000 to 4,000 H for very dense bone. H Units are not absolute values but, rather, are relative values that may vary from one CT system to another.

In general, bone is +400 to +1,000 HU, soft tissue is +40 to +80 HU, fat is -60 to -100 HU, lung tissue is -400 to -600 HU, and air is -1,000 HU.



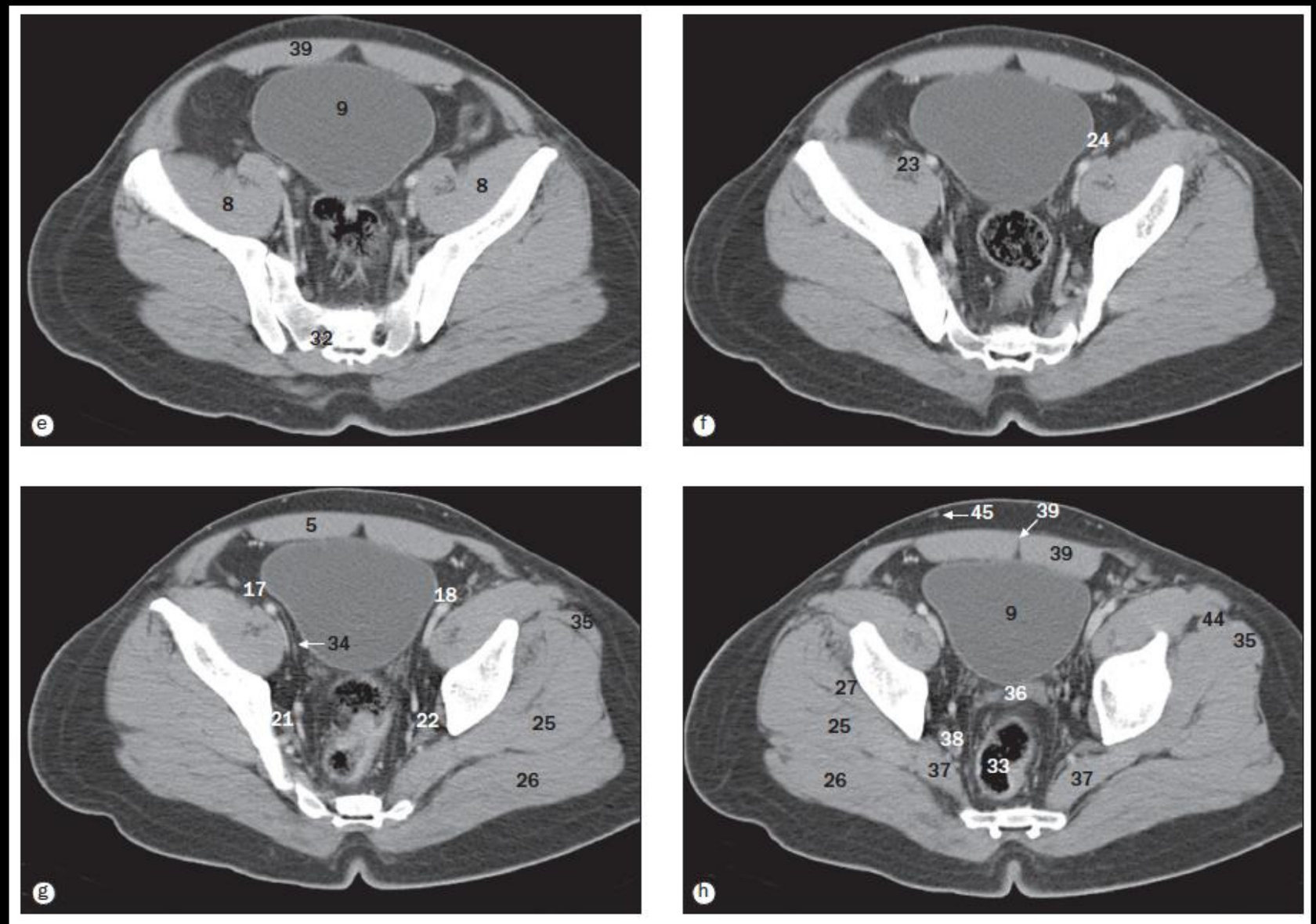
The CT Hounsfield scale places water density at a value of zero with air and bone at opposite extreme values of -1000 and +1000. The colors associated with these density values can be reassigned to highlight particular tissues, a process called "windowing." © 2007 Joshua Broder.

- In CT scan we use different windows according to the clinical case and the area examined, for example in MSK system we must examine the patient in both soft tissue window and bone window.

- If the lesion is in the bone, then bone window will give better details .

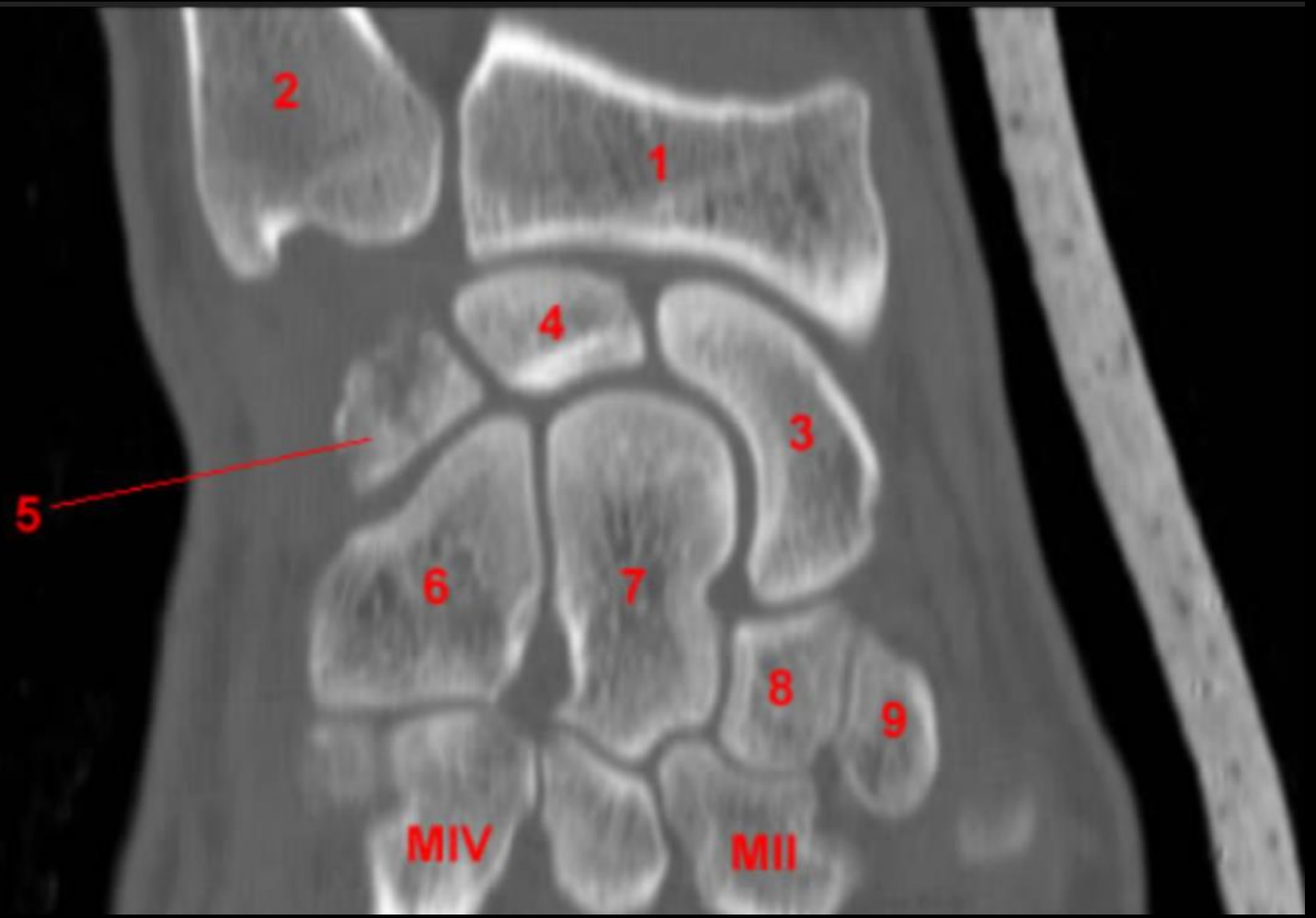

A
R
L
P

CT scan of the pelvis, which window is it ?

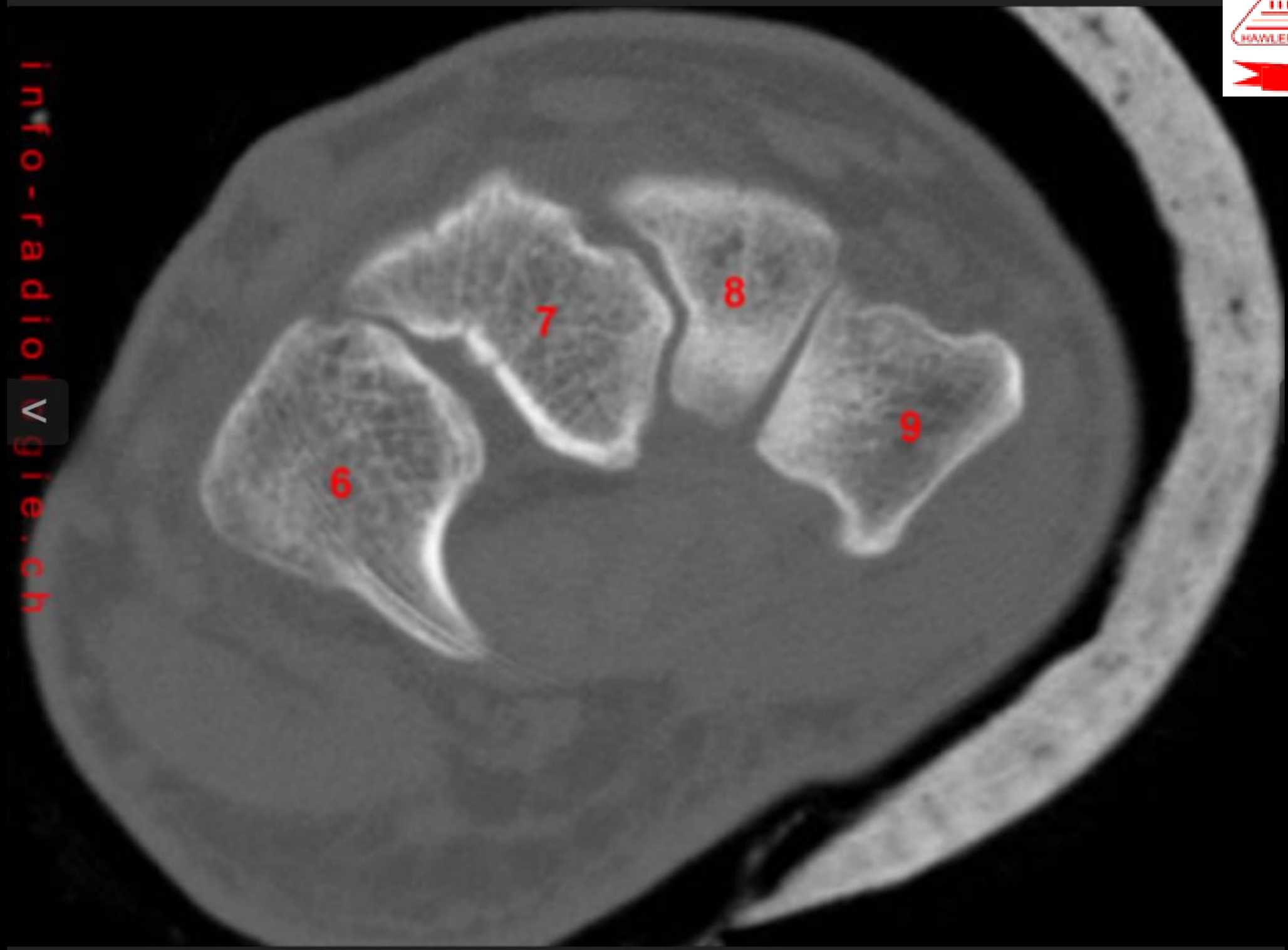


25 Gluteus medius muscle
26 Gluteus maximus muscle
27 Gluteus minimus muscle
28 Sigmoid colon
29 Sacrum
30 Sacral alum
31 Sacroiliac joint
32 Sacral foramen
33 Rectum
34 Vas deferens
35 Tensor fasciae latae muscle
36 Seminal vesicle
37 Piriformis muscle
38 Superior gluteal artery and vein
39 Linea alba
40 External oblique muscle
41 Internal oblique muscle
42 Transversus abdominis muscle
43 Thecal sac
44 Sartorius muscle
45 Superficial inferior epigastric artery

CT of the wrist: anatomy. Coronal view. Image 12. 1, Radius. 2, Ulna. 3, Scaphoid. 4, Lunate. 5, Triquetrum. 6, Hamate. 7, Capitate. 8, Trapezoid. 9, Trapezium. M1 to MV Base of metacarpal I to V.

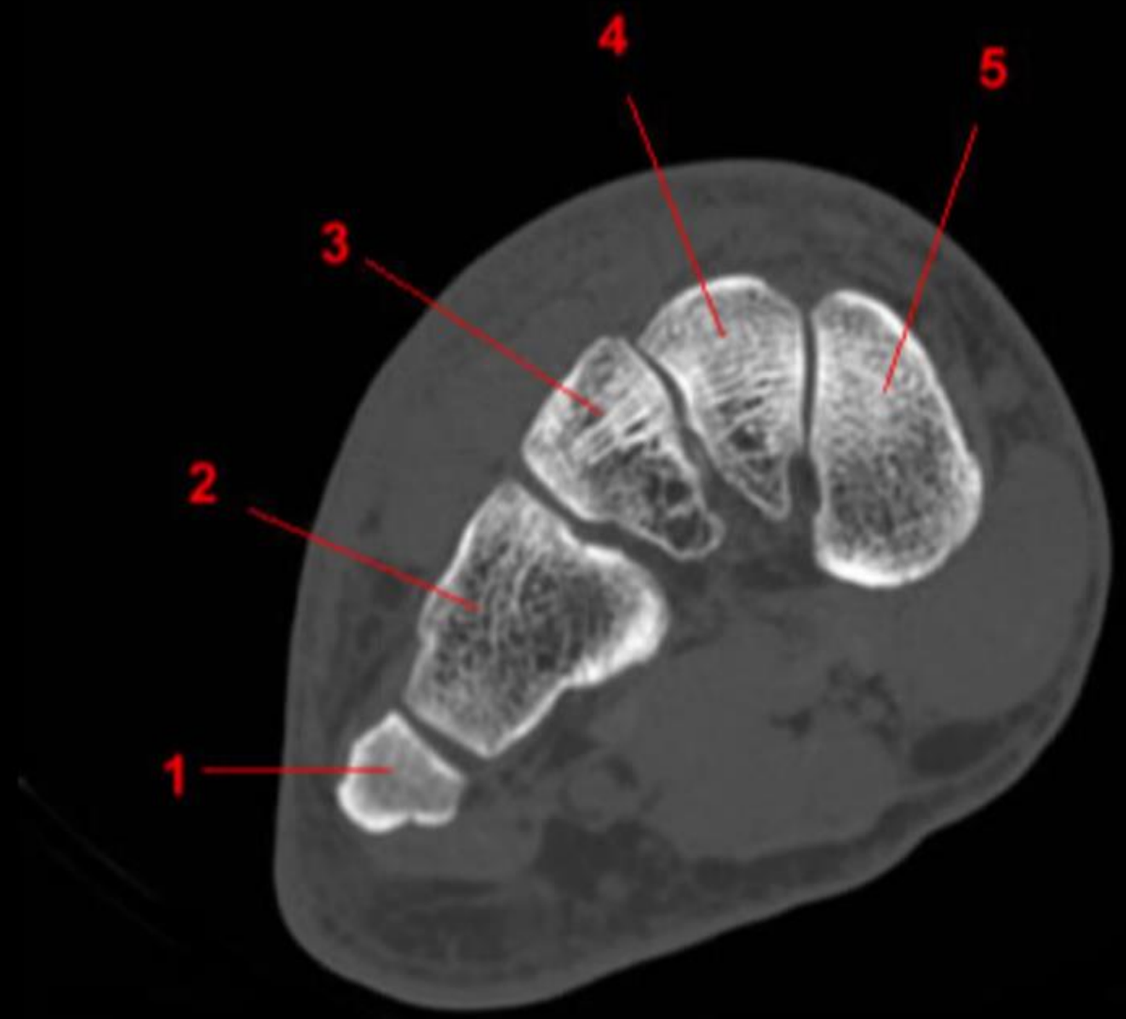


CT of the wrist: anatomy. Axial view. Image 11. 6, Hamate. 7, Capitate. 8, Trapezoid. 9, Trapezium.

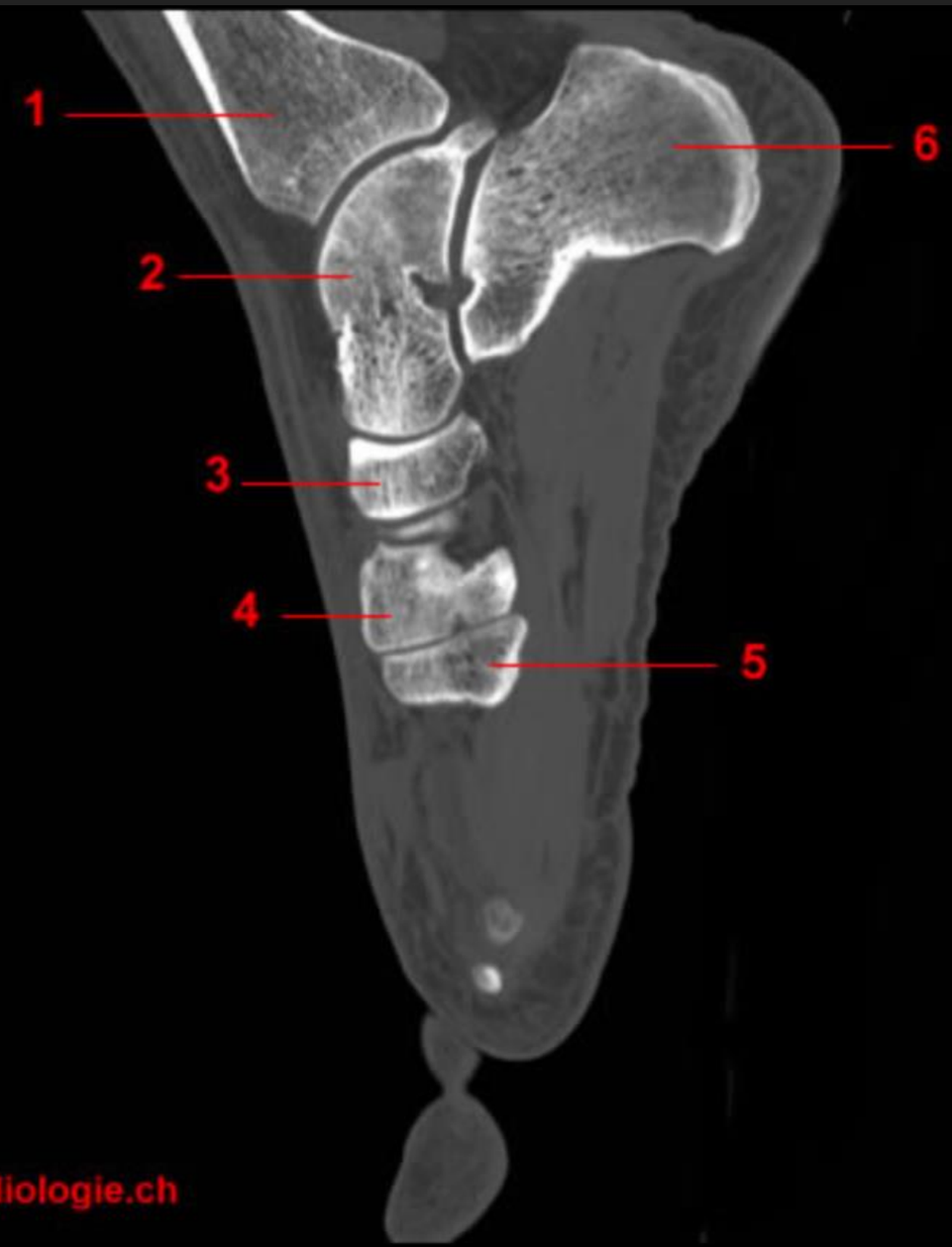


CT of the wrist: anatomy. Sagittal view. Image 8. 1, Radius. 4, Lunatum. 7, Capitate. M1 to MV Base of metacarpal I to V.

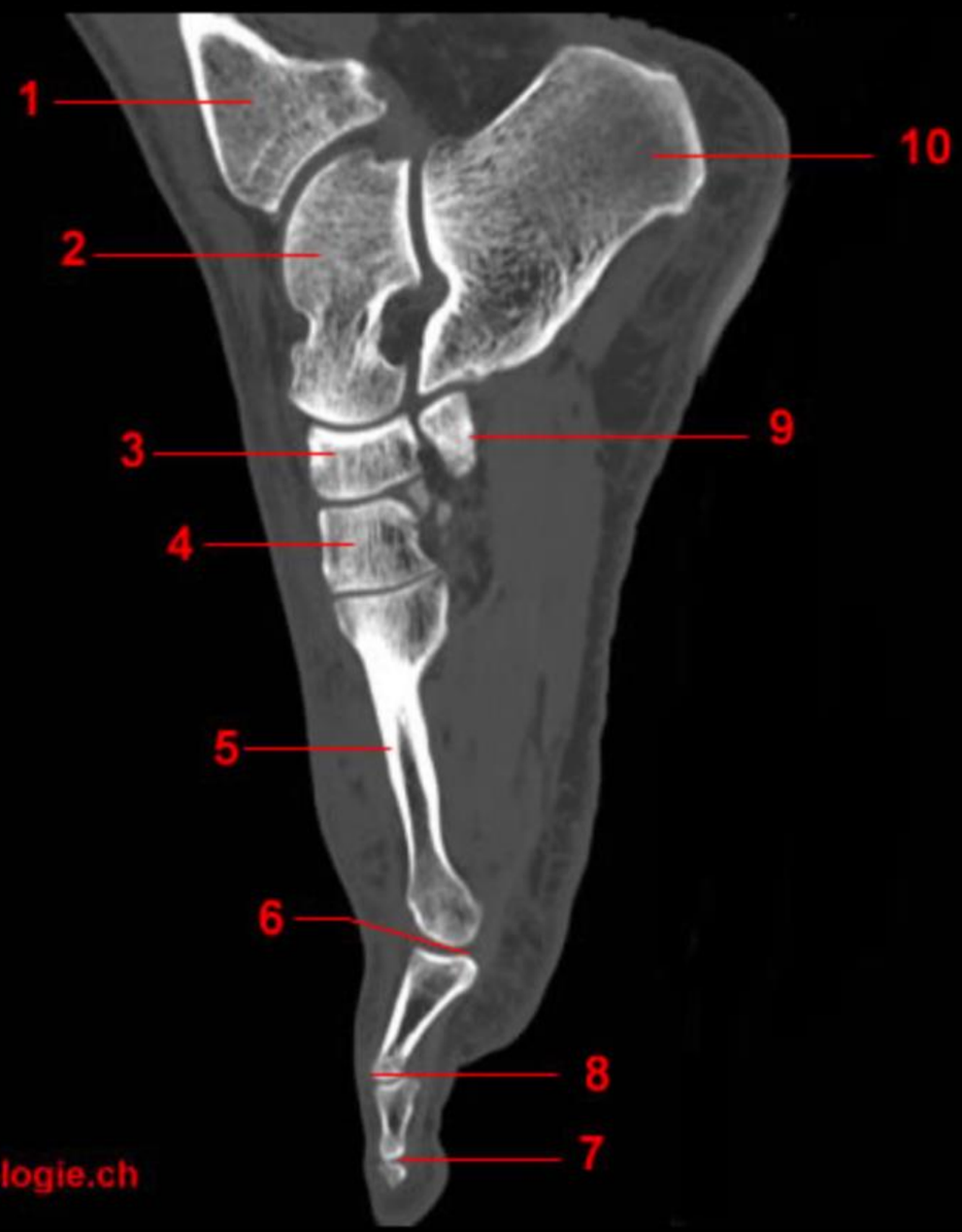
CT-scan of the ankle (axial reconstruction). Image 18. 1, 5th metatarsal. 2, Cuboid. 3, Lateral cuneiform. 4, Intermediate cuneiform. 5, Medial cuneiform.



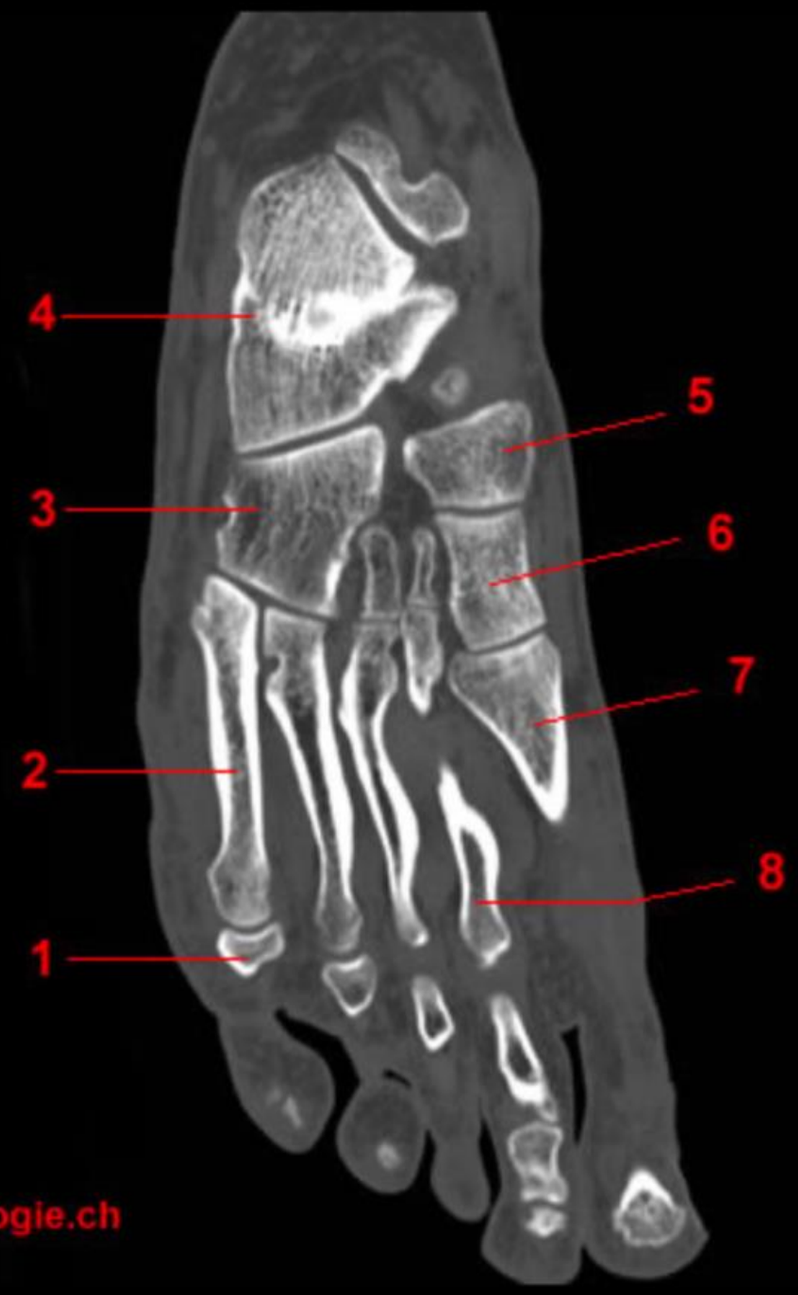
CT-scan of the ankle (sagittal reconstruction). Image 8. 1, Tibia. 2, Talus. 3, Navicular. 4, Medial cuneiform. 5, Base of 1st metatarsal. 6, Calcaneus.



CT-scan of the ankle (sagittal reconstruction). Image 10. 1, Tibia. 2, Talus. 3, Navicular. 4, Intermediate cuneiform. 5, 2nd metatarsal. 6, Metatarsophalangeal joint. 7, Distal interphalangeal joint. 8, Proximal interphalangeal joint. 9, Cuboid. 10, Calcaneus.



CT-scan of the ankle (coronal reconstruction). Image 14. 1, Base of 5th proximal phalanx. 2, 5th metatarsal. 3, Cuboid. 4, Calcaneus. 5, Navicular. 6, Medial cuneiform. 7, Base of 1st metatarsal. 8, 2nd metatarsal.



CT-scan of the ankle (coronal reconstruction). Image 9. 1, Fibula. 2, Tibia. 3, Talus. 4, Navicular. 5, Intermediate cuneiform. 6, Medial cuneiform. 7, Base of 2nd metatarsal. 8, Lateral cuneiform.

Magnetic resonance Imaging
(MRI)

MR is a technique that produces tomographic images by means of magnetic fields and radio waves.

MRI analyzes multiple tissue characteristics, including hydrogen (proton) density, T1 and T2 relaxation times of tissue, and blood flow within tissue.

In the simplest terms, MR is based on the ability of a small number of protons within the body to absorb and emit radio wave energy when the body is placed within a strong magnetic field.

Different tissues absorb and release radio wave energy at different, detectable, and characteristic rates.

Present MR technology relies on a variety of MR sequence techniques (T1 weighted images, T2 weighted Images, Fat Suppressions images …etc) , with many variations used by different MR manufacturers .

- In MRI we uses the term Signal intensity to describe different tissue appearances .

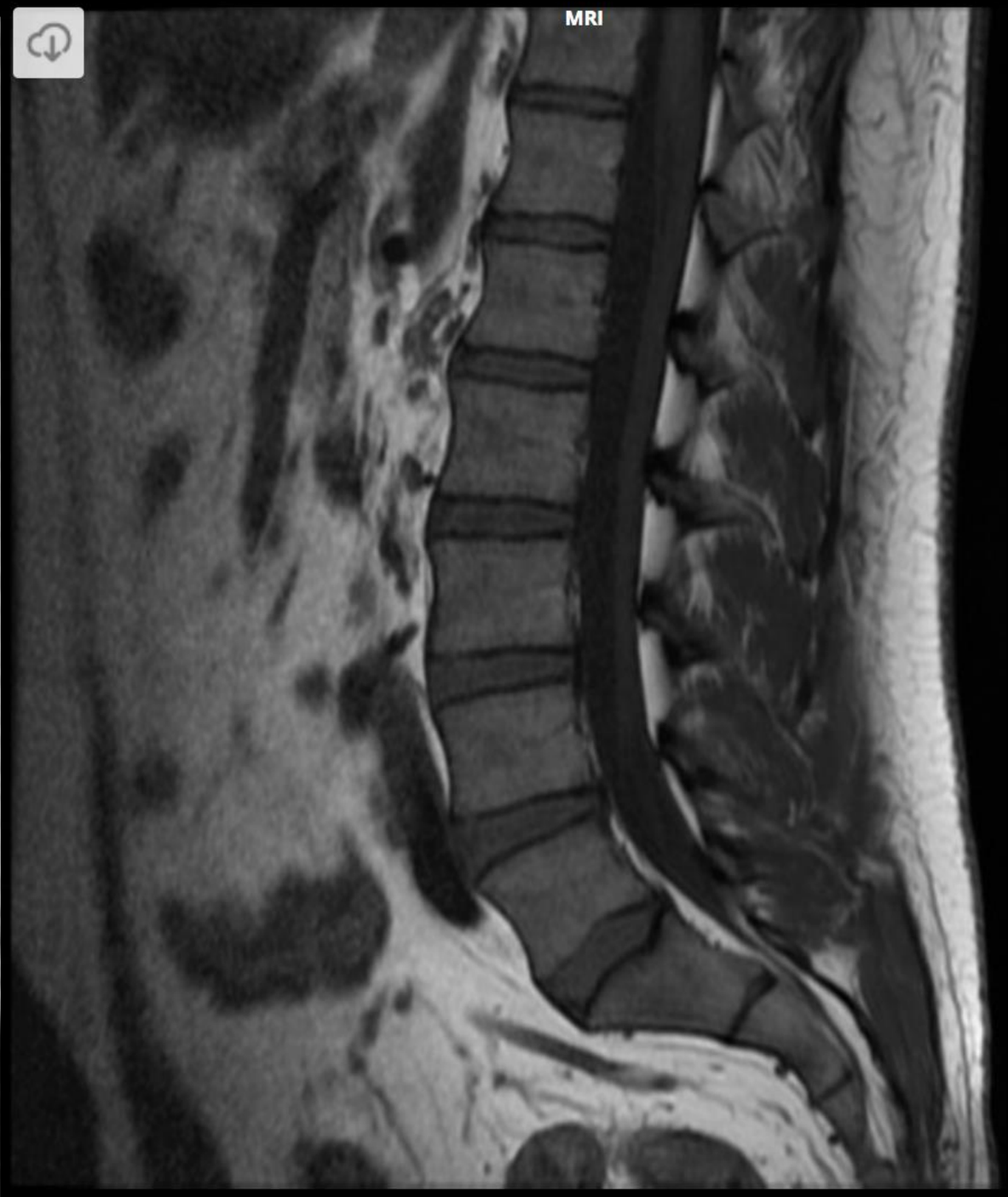
- The tissue intensity depends on their water hydrogen content and the sequence used

- We have spin echo sequences (T1 and T2 weighted Images), Fat suppression sequences and so many more.

- Free extracellular fluid appear hyperintense on T1WI and hypo intense on T2WI , unless it has high protein content (like pus), then it appear hyper intense on both .

- Mineral-rich structures, such as bone and calculi, and collagenous tissues, such as ligaments, tendons, fibrocartilage, and tissue fibrosis, are low in water content and lack mobile protons to produce an MR signal, **These tissues are low in signal intensity on all MR sequences.**

What is the difference between these two images?



Muscle and other soft tissue organs like liver or spleen , have intermediate signal intensities on both T1WIs and T2WIs but muscles have lower signal intensity on T1WIs than other soft tissue organs.

Hyaline cartilage has a predominance of extracellular water, but the water is extensively bound to a mucopolysaccharide matrix. Its signal characteristics resemble cellular soft tissues, and it is intermediate in strength on most imaging sequences.

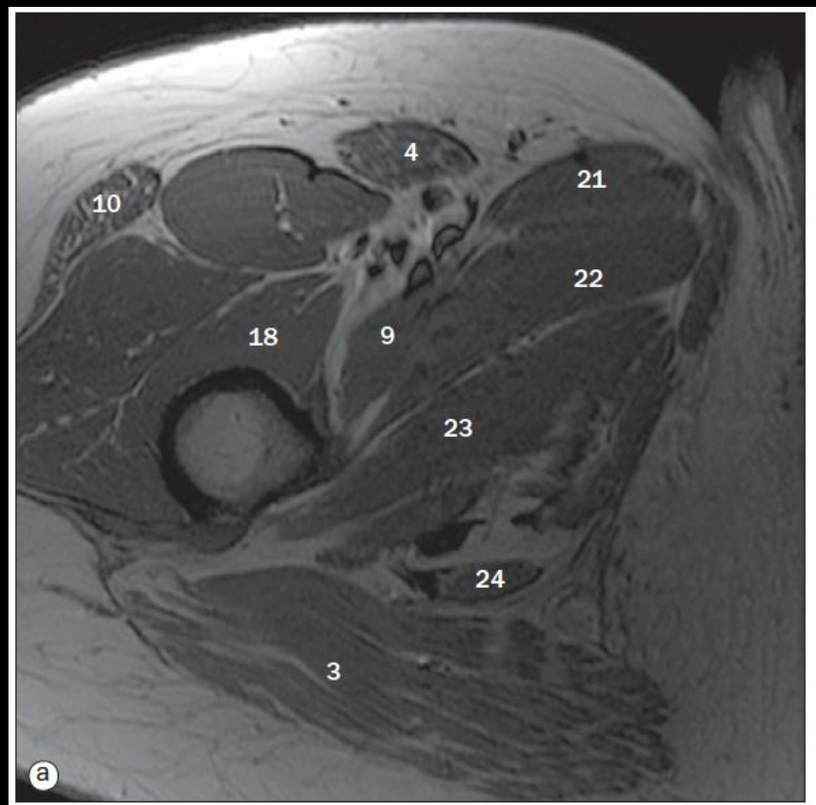
Fat

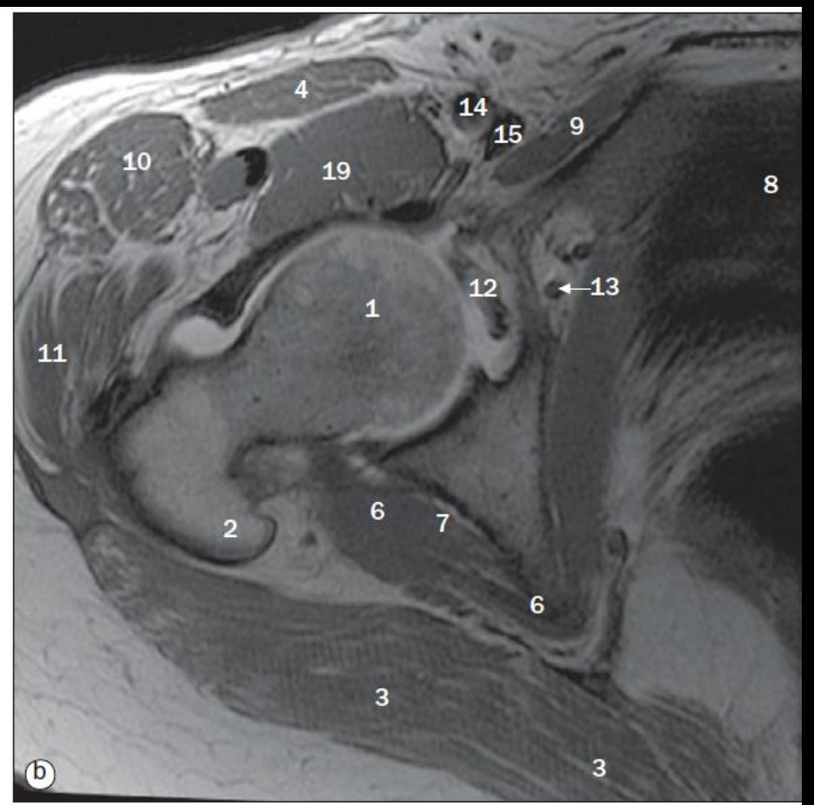
Fat appear bright on both sequences (T1WIs and T2WIs but more bright on T1WIs) and can be suppressed on special fat suppression sequences (e.g, STIR sequence)

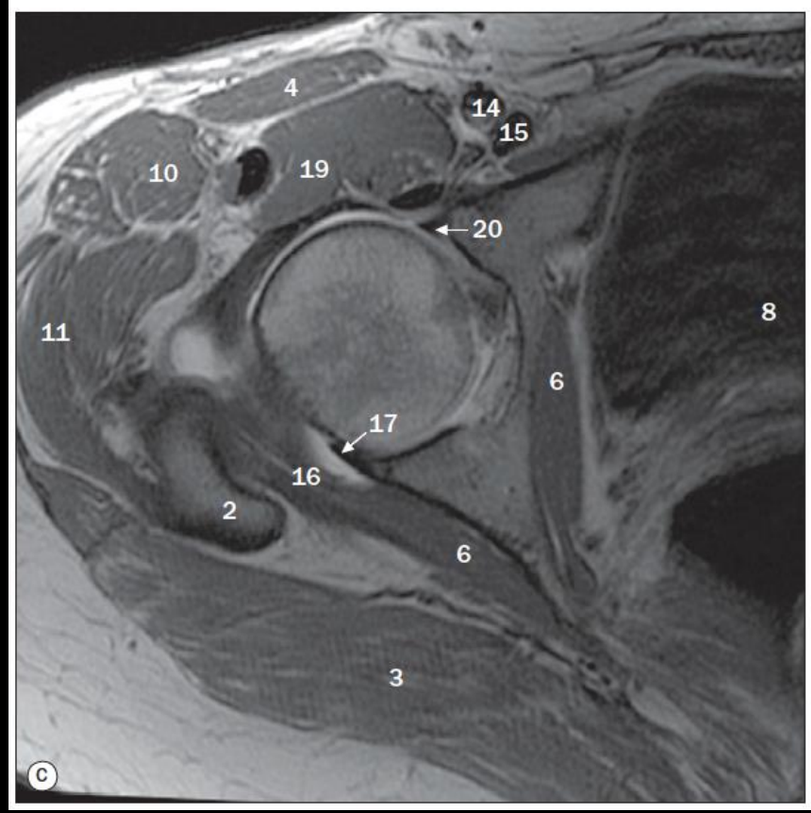
Flowing Blood

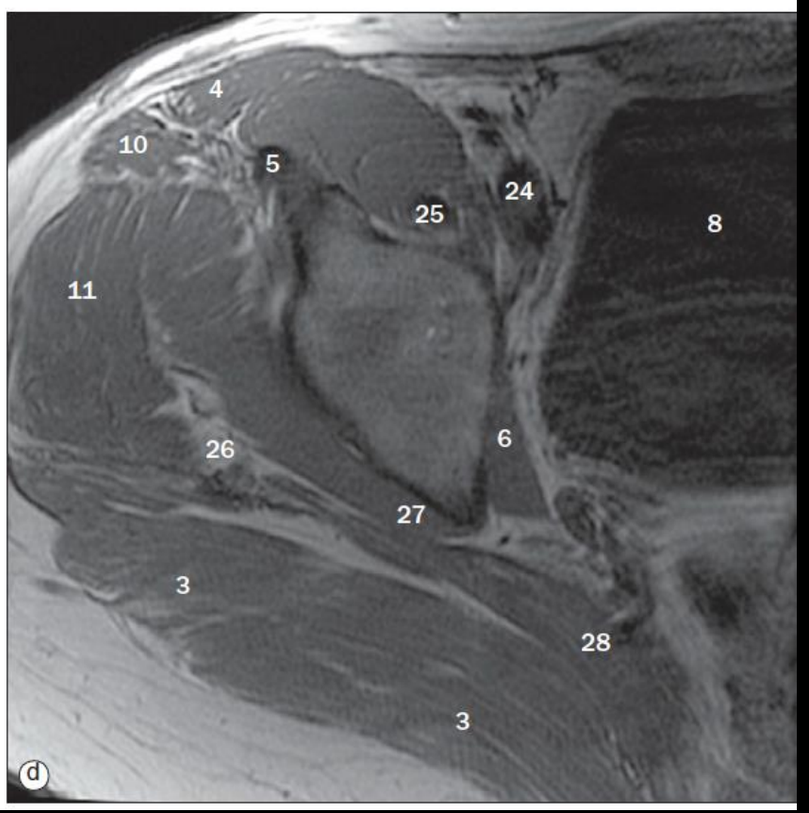
The MR signal of slow-moving blood, such as in the spleen, venous plexuses, and cavernous hemangiomas, is dominated by the large amount of extracellular water present, resulting in low signal on T1WIs and high signal on T2WIs.

Higher-velocity blood flow, however, alters the MR signal in complex ways, resulting in signal loss (black blood) or bright signal intensity (white blood) according to the sequences used.



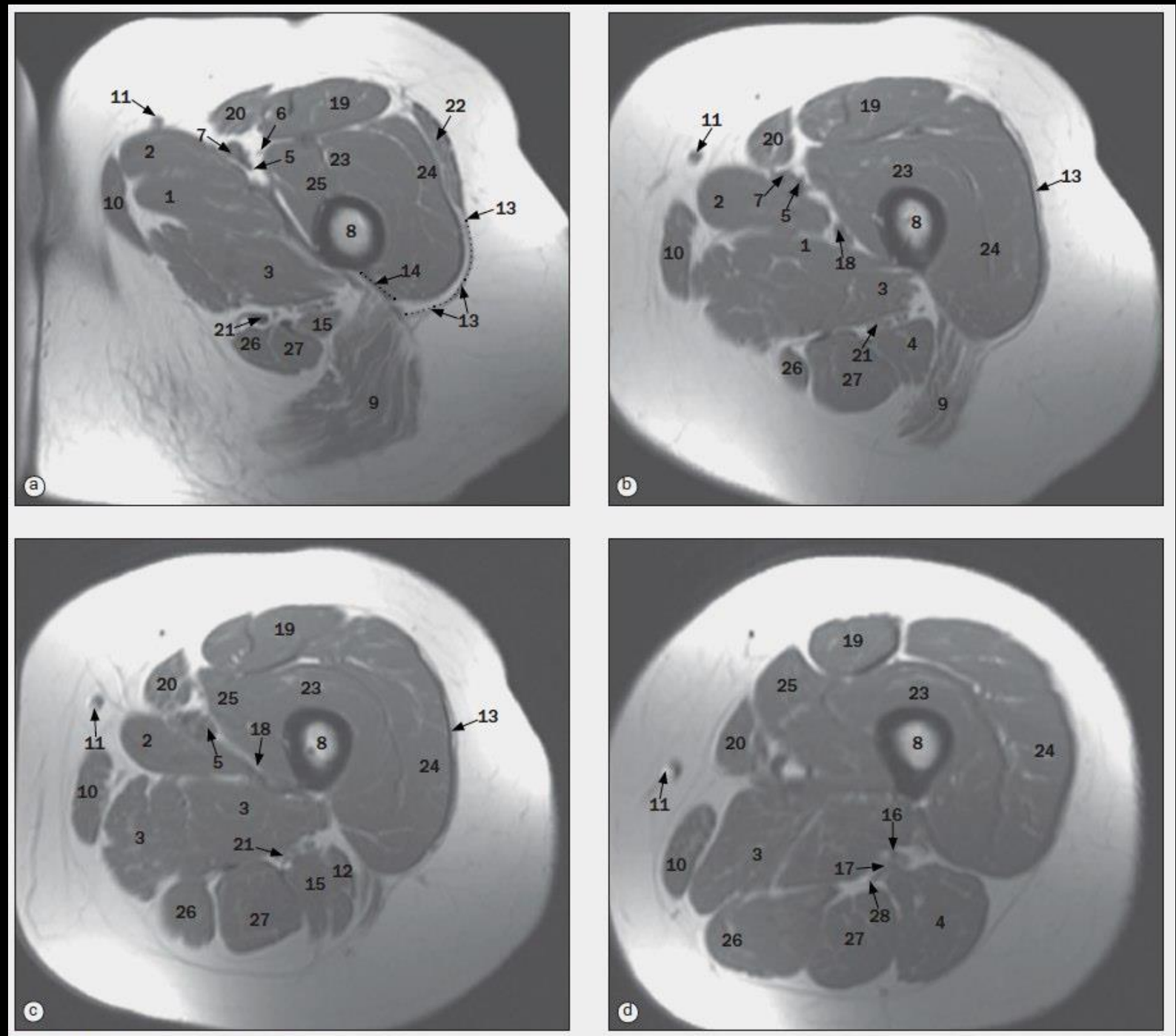






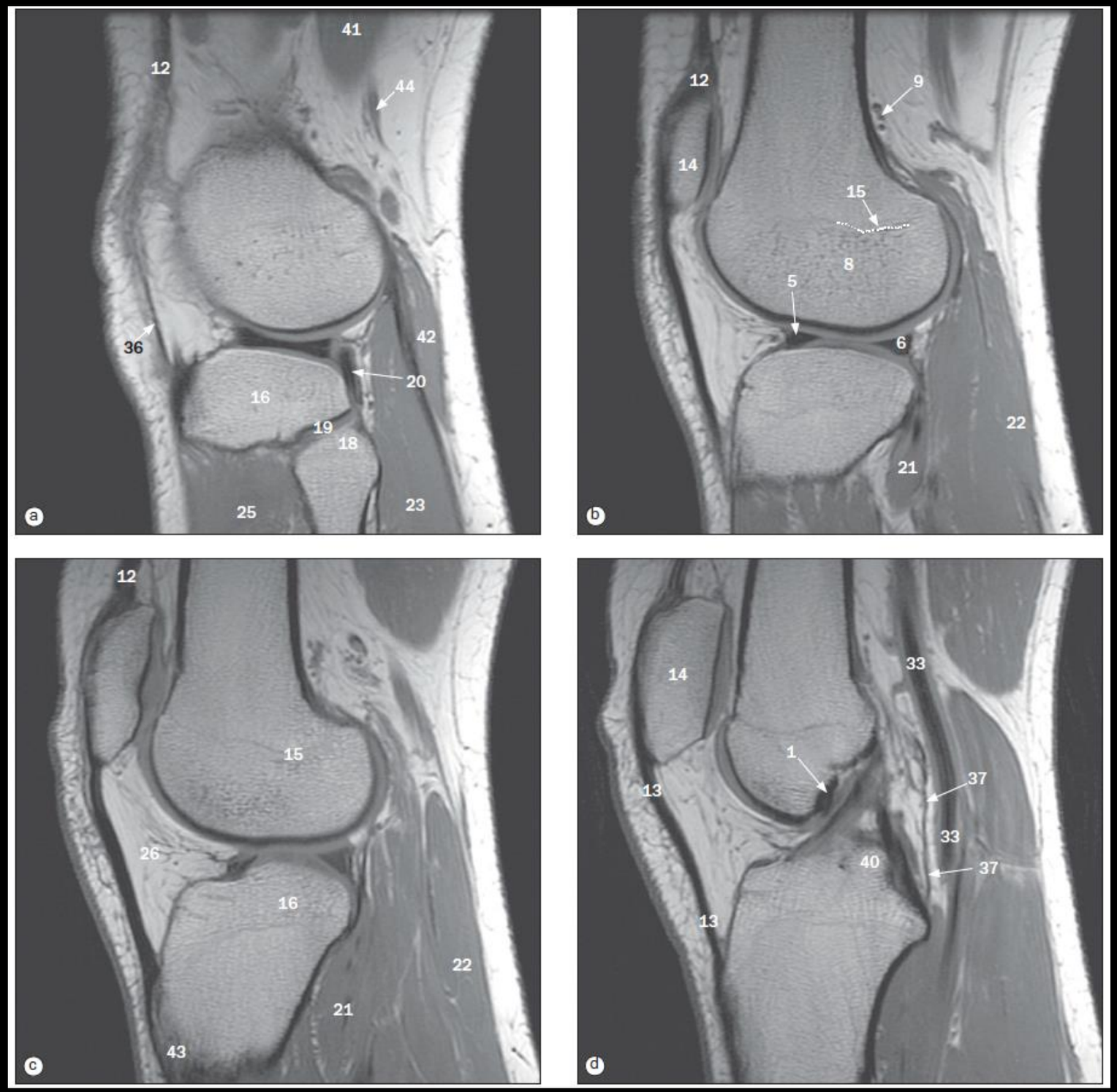
Transverse MR images of the right hip:

1 Femoral head
2 Greater trochanter
3 Gluteus maximus muscle
4 Sartorius muscle
5 Tendon of rectus femoris muscle
6 Obturator internus muscle
7 Superior gemellus muscle
8 Bladder
9 Pectineus muscle
10 Tensor fascia lata muscle
11 Vastus lateralis muscle
12 Ligamentum teres
13 Obturator nerve
14 Femoral artery
15 Femoral vein
16 Tendon of obturator internus muscle
17 Posterior acetabular labrum
18 Vastus intermedius muscle
19 Iliopsoas muscle
20 Anterior acetabular labrum
21 Adductor longus muscle
22 Adductor brevis muscle
23 Adductor magnus muscle
24 Semitendinosus muscle
25 Profunda femoris artery
26 External iliac artery
27 Gluteus minimus muscle
28 Gluteus medius muscle



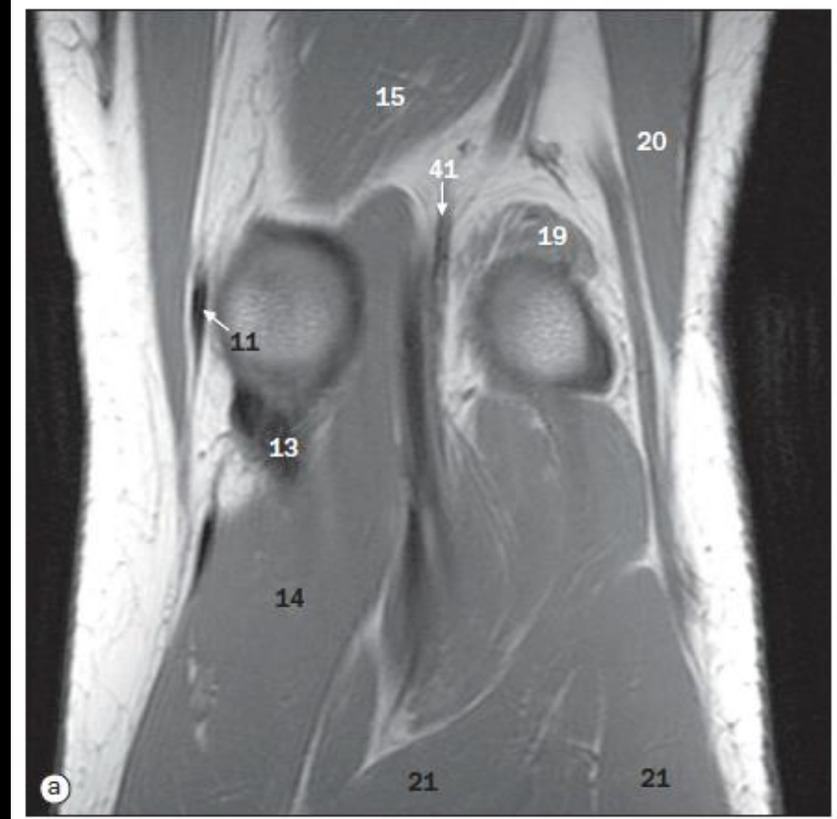
(a)–(d) Axial MR images of the thigh.

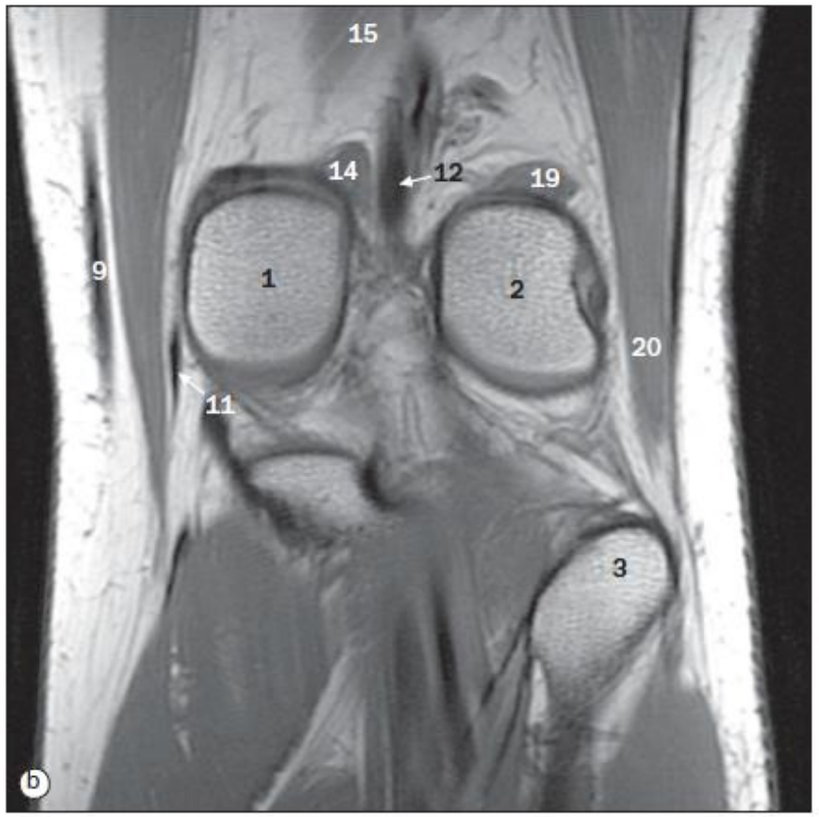
1 Adductor brevis muscle
2 Adductor longus muscle
3 Adductor magnus muscle
4 Biceps femoris muscle
5 Femoral artery
6 Femoral nerve
7 Femoral vein
8 Femur
9 Gluteus maximus muscle
10 Gracilis muscle
11 Great (long) saphenous vein
12 Short head of biceps femoris muscle
13 Iliotibial tract
14 Lateral intermuscular septum
15 Long head of biceps femoris muscle
16 Popliteal artery
17 Popliteal vein
18 Profunda femoris artery
19 Rectus femoris muscle
20 Sartorius muscle
21 Sciatic nerve
22 Tensor fasciae latae muscle
23 Vastus intermedius muscle
24 Vastus lateralis muscle
25 Vastus medialis muscle
26 Semimembranosus muscle
27 Semitendinosus muscle
28 Tibial nerve

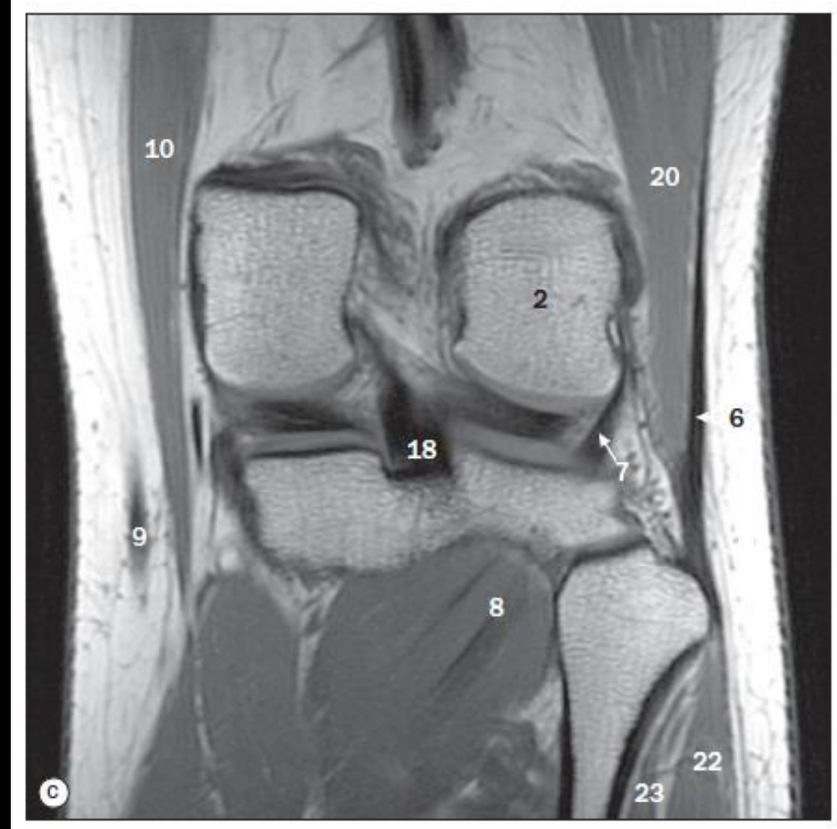


Sagittal MR Images of the knee joint :

1 Anterior cruciate ligament
2 Posterior cruciate ligament
3 Anterior horn medial meniscus
4 Posterior horn medial meniscus
5 Anterior horn lateral meniscus
6 Posterior horn lateral meniscus
7 Medial condyle of femur
8 Lateral condyle of femur
9 Lateral superior genicular artery and veins
10 Median intermuscular septum
11 Medial superior genicular artery
12 Quadriceps tendon
13 Patellar tendon
14 Patella
15 Epiphyseal line/scar
16 Lateral tibial plateau
17 Medial tibial plateau
18 Fibular head
19 Proximal tibiofibular joint
20 Popliteus tendon
21 Popliteus muscle belly
22 Lateral head of gastrocnemius muscle
23 Soleus muscle
24 Vastus medialis muscle

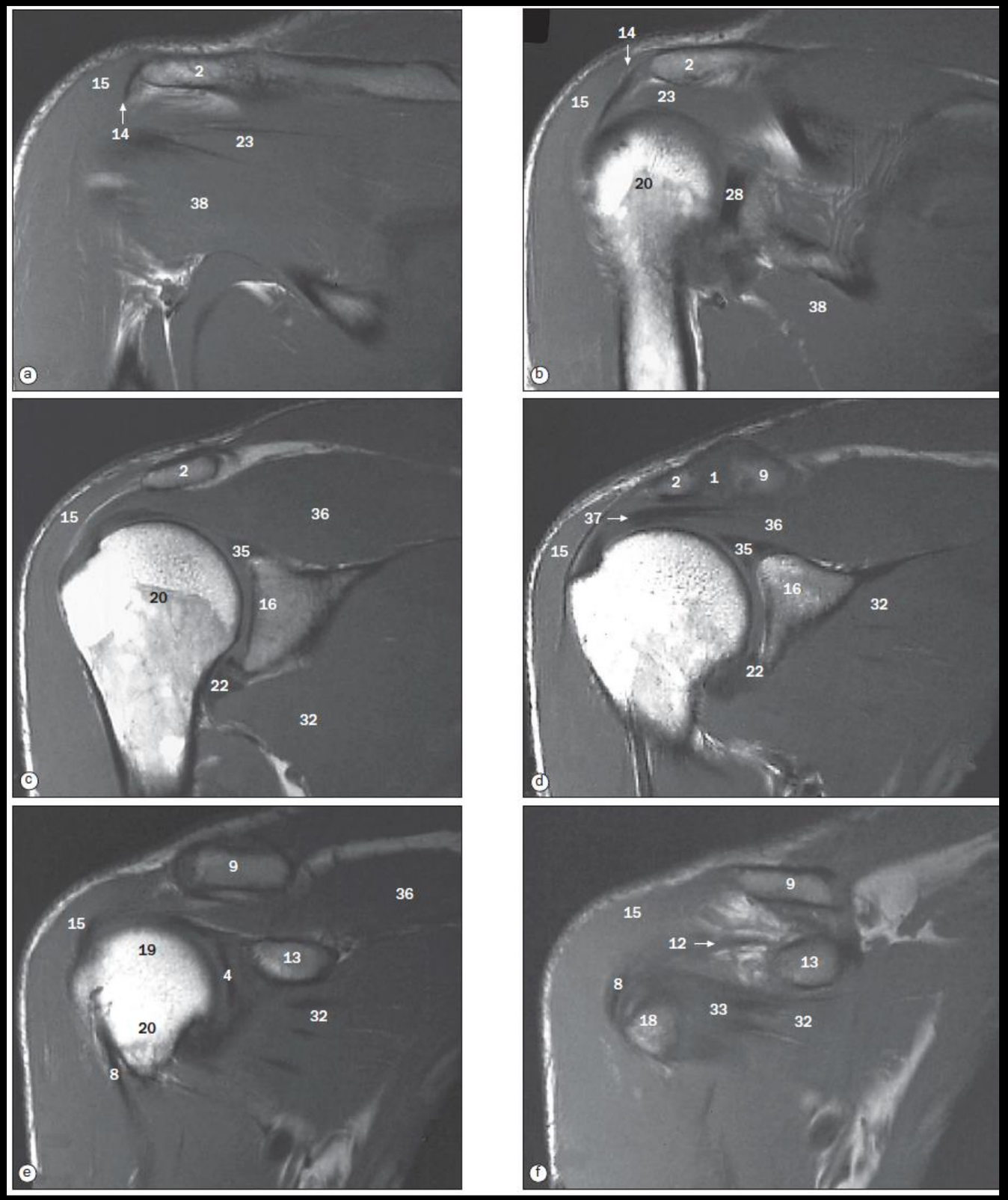






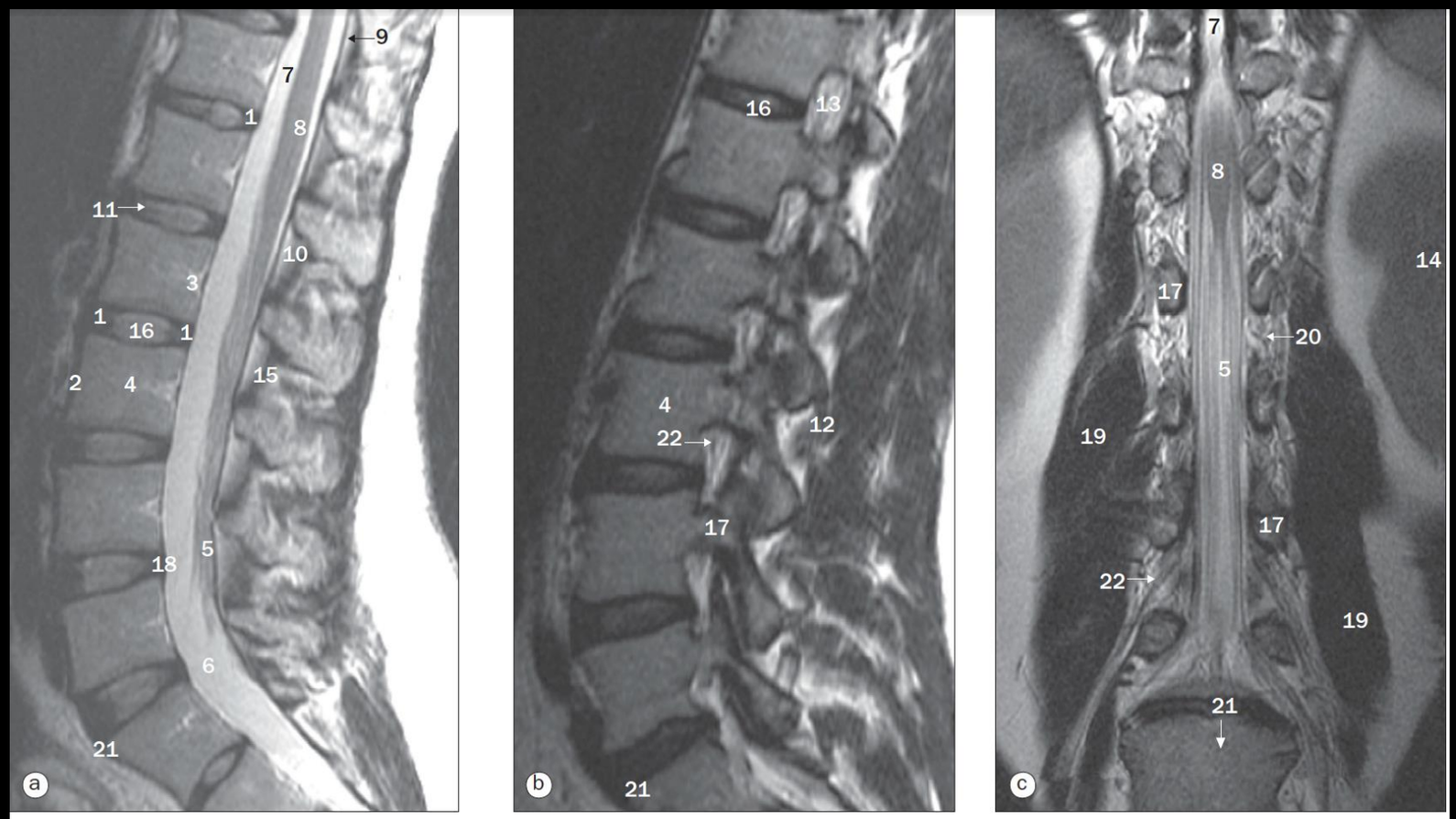
Coronal MR Images of the knee joint:

1 Medial femoral condyle
2 Lateral femoral condyle
3 Head of fibula
4 Proximal tibiofibular joint
5 Lateral collateral ligament
6 Iliotibial tract
7 Tendon of popliteus muscle
8 Popliteus muscle
9 Great (long) saphenous vein
10 Sartorius muscle
11 Tendon of gracilis muscle
12 Popliteal artery
13 Common peroneal (fibular) nerve
14 Medial head of gastrocnemius muscle
15 Semimembranosus muscle
16 Posterior horn medial meniscus
17 Posterior horn lateral meniscus
18 Posterior cruciate ligament
19 Lateral head of gastrocnemius
20 Biceps femoris muscle
21 Soleus muscle
22 Peroneus (fibularis) longus muscle
23 Extensor digitorum longus muscle
24 Anterior cruciate ligament



Coronal MR Images of the shoulder joint:

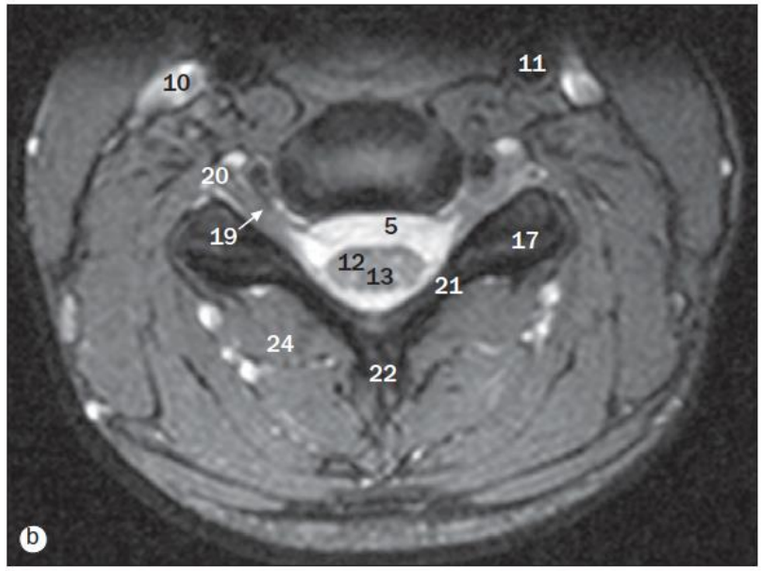
1 Acromioclavicular joint
2 Acromion
3 Anterior capsule of shoulder joint
4 Anterior labrum
5 Axillary artery and vein
6 Axillary recess
7 Biceps brachii tendon
8 Biceps brachii tendon (long head)
9 Clavicle
10 Coracobrachialis muscle
11 Coracoclavicular ligament
12 Coracohumeral ligament
13 Coracoid process
14 Deltoid tendon
15 Deltoid muscle
16 Glenoid
17 Glenoid labrum
18 Greater tuberosity
19 Head of humerus
20 Humerus
21 Inferior glenohumeral ligament
22 Inferior labrum
23 Infraspinatus muscle
24 Infraspinatus tendon
25 Middle glenohumeral ligament
26 Pectoralis minor muscle
27 Posterior capsule of shoulder joint
28 Posterior labrum
29 Rotator cuff
30 Scapula
31 Spine of scapula
32 Subscapularis muscle
33 Subscapularis tendon
34 Superior glenohumeral ligament
35 Superior labrum
36 Supraspinatus muscle
37 Supraspinatus tendon
38 Teres minor muscle
39 Trapezius muscle

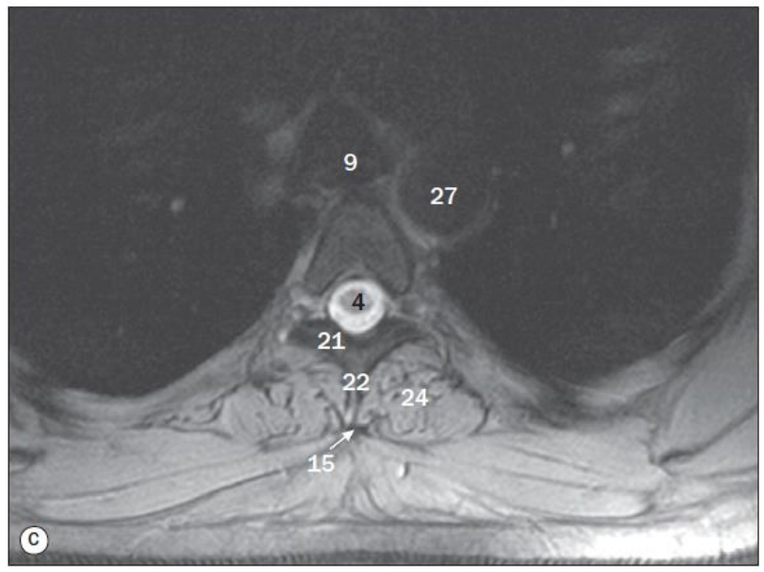


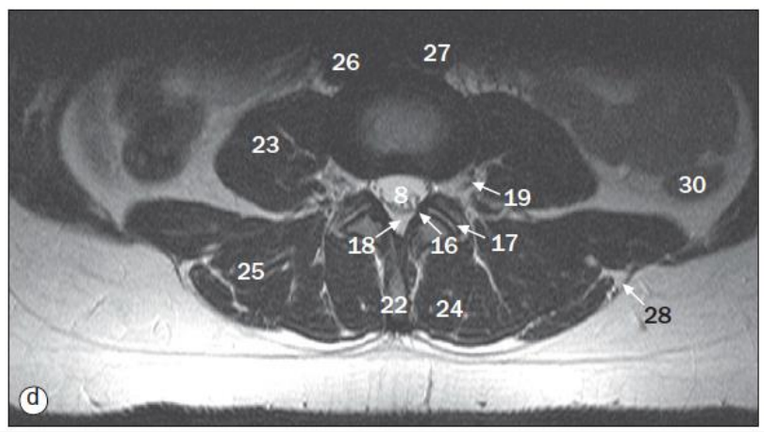
Lumbosacral spine, (**a**) sagittal MR image, (**b**) parasagittal MR image, (**c**) coronal MR image.

MRI of the Lumbosacral spine :

1 Annulus fibrosus
2 Anterior longitudinal ligament
3 Basivertebral vein
4 Body of third lumbar vertebra
5 Cauda equina
6 Caudal lumbar thecal sac
7 Cerebrospinal fluid
8 Conus medullaris
9 Dural sac
10 Epidural space (fat filled)
11 Internuclear cleft
12 Interspinous ligament
13 Intervertebral foramen
14 Kidney
15 Ligamentum flavum
16 Nucleus pulposus
17 Pedicle
18 Posterior longitudinal ligament and annulus fibrosus
19 Psoas muscle
20 Radicular vessels
21 Sacral promontory
22 Spinal nerve root in intervertebral foramen







MR images of the spine, (a) sagittal T2 wide field of view and axial T2 sections from the (b) cervical, (c) thoracic and (d) lumbar regions.

1 Foramen magnum
2 Body of C7
3 Nucleus pulposus of T5/6 intervertebral disc
4 Spinal cord
5 CSF in subarachnoid space (flow void artefact)
6 Basivertebral vein
7 Conus medullaris
8 Cauda equina
9 Trachea
10 Internal jugular vein
11 Common carotid artery
12 Grey matter of spinal cord
13 White matter of spinal cord
14 Spinous process of T4
15 Supraspinous ligament
16 Ligamentum flavum
17 Facet (zygapophyseal) joint
18 Epidural fat
19 Dorsal root ganglion
20 Spinal nerve root
21 Lamina
22 Spinous process
23 Psoas major muscle
24 Erector spinae muscle
25 Multifidus muscle
26 Inferior vena cava
27 Aorta
28 Thoracolumbar fascia
29 Ligamentum nuchae
30 Descending colon

References

- Fundamentals of Diagnostic radiology, William E. Brant

- http://w-radiology.com/index.html